

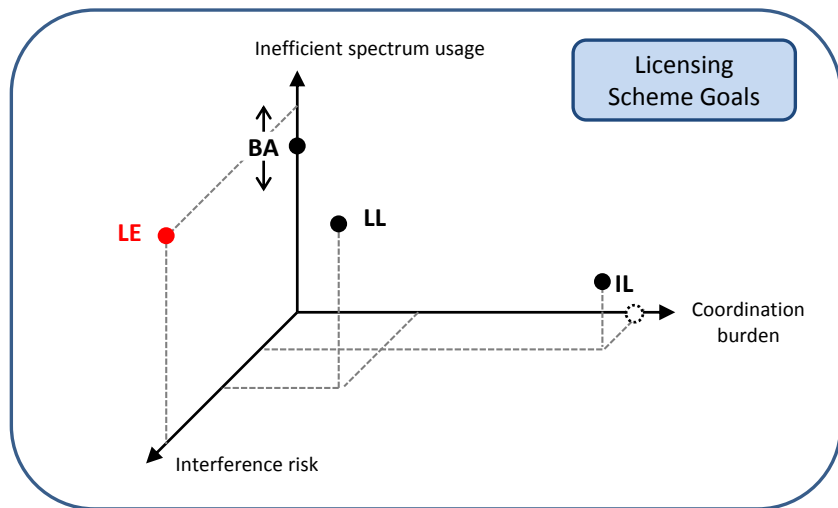
Evolution of Fixed Services for wireless backhaul of IMT 2020 / 5G

- **Wireless Backhaul for IMT 2020 / 5G - Overview and introduction**
by Renato Lombardi, Huawei
- **Wireless X-Haul Requirements**
by Nader Zein, NEC
- **Microwave and millimeter-wave technology overview and evolution**
by Mario Frecassetti, Nokia
- **Operator's view on frequency use related challenges for microwave and millimeter-wave in IMT 2020/ 5G backhaul/X-Haul**
by Paolo Agabio, Vodafone
- **Panel discussion:**
Economics on deployment and operational aspects of microwave and millimeter-wave technology in IMT 2020 / 5G mobile backhaul/X-Haul network



Backhaul spectrum licensing schemes as of today

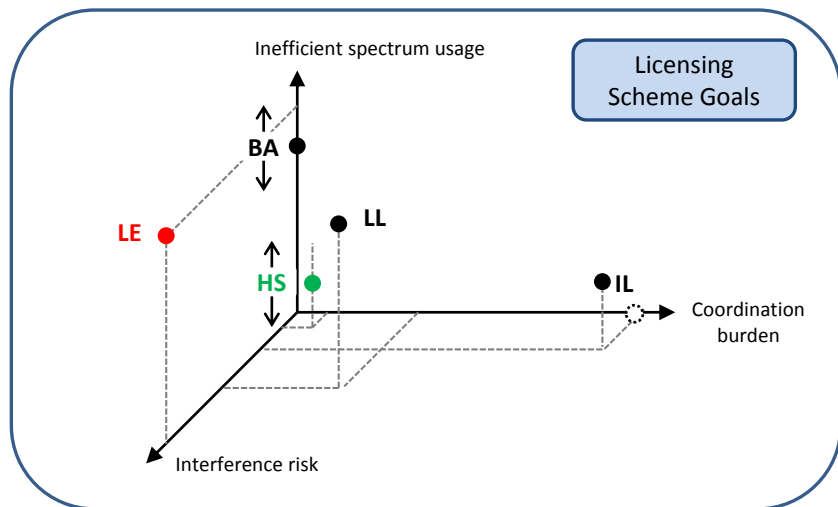
License scheme	Application	Coordination	Cases
Individual Licensing (IL)	Link-by-link	By the Administration	Most used
Light Licensing (LL)	Link-by-link	Licensee responsibility	Limited (E-Band in UK)
Block Assignment (BA)	Public auction & Direct assignment	Guard Bands	FWA (26, 28 GHz)
License Exempt (LE)	Free	No guarantee	Very limited (V-Band)



- Administrations (NRA) and Operators (MNO) share same goals to minimize
 - Coordination burden = Costs & Time To Market
 - Interference risk
 - Inefficient spectrum usage
- Unfortunately **none of existing licensing schemes can minimize all the above**
 - License Exempt is not an option for Backhaul, especially moving towards 5G that shall support also mission critical applications

Backhaul spectrum licensing schemes: a new hybrid approach

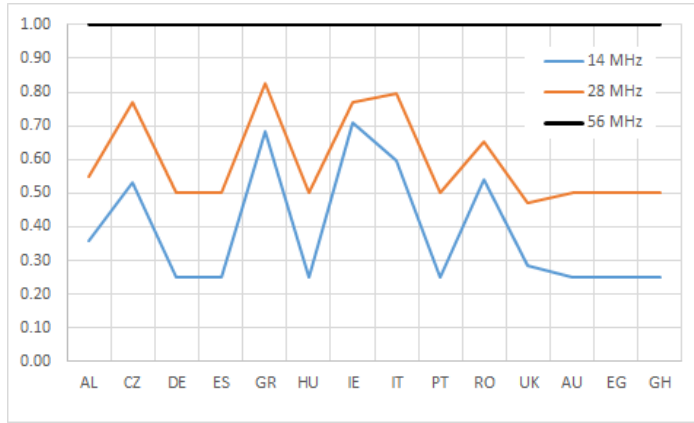
License scheme	“Hybrid scheme” (HS)
Application	Block reservation for the MNO and link-by-link declaration by the MNO; NRA is aware of actual spectrum utilization (for assessing an efficient spectrum usage)
Coordination	MNO managing self-coordination within the Block; coordination among MNOs using adjacent blocks ensured by filter + antenna discrimination and guard bands (if needed)
Cases	Used (e.g. Romania, Turkey)



- By leveraging and mixing the best of Individual Licensing and Block Assignment
- **“Hybrid Scheme” has the potential to achieve all three goals**
 - By managing the efficient spectrum usage by proper license fees rules
 - with a low up-front fee for block reservation
 - and additional fee per link that incentivize Operators to stay within the block as much as possible

Backhaul spectrum licensing fees as of today: Individual licensing

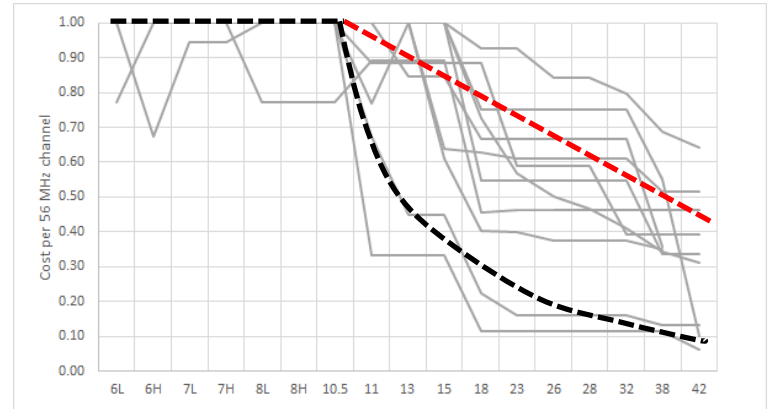
15-23 GHz Band: channel width cost



- In most of Countries license fees decreases linearly when **moving to higher bands**

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56 MHz channel cost vs Band



This is not sustainable in the long term for 4G and 5G backhaul

Backhaul spectrum licensing fees: sustainability in the long term

License scheme	License fees – MNO considerations
Individual Licensing (IL)	Not sustainable with current approach
Light Licensing (LL)	OK
Block Assignment (BA)	Too high investments up-front
License Exempt (LE)	Not applicable
Hybrid Scheme (HS)	Opportunity for best trade-off

- **Individual Licensing** and **Block Assignment** (as is today) are not affordable anymore
- **Light Licensing** is OK from fee perspective but it does not guarantee an efficient spectrum use
- **License Exempt** is not considered because of unaffordable interference risks
- **Hybrid Scheme** is most interesting license regime to be considered, allowing to trade-off among up-front investments, efficient spectrum usage and overall spectrum cost for MNO
- Huge spectrum cost variations Country by Country result in difficulties for Global MNO to develop a single strategy

New technologies, new bands and higher spectrum demand for 5G X-haul deserve new license fees approach

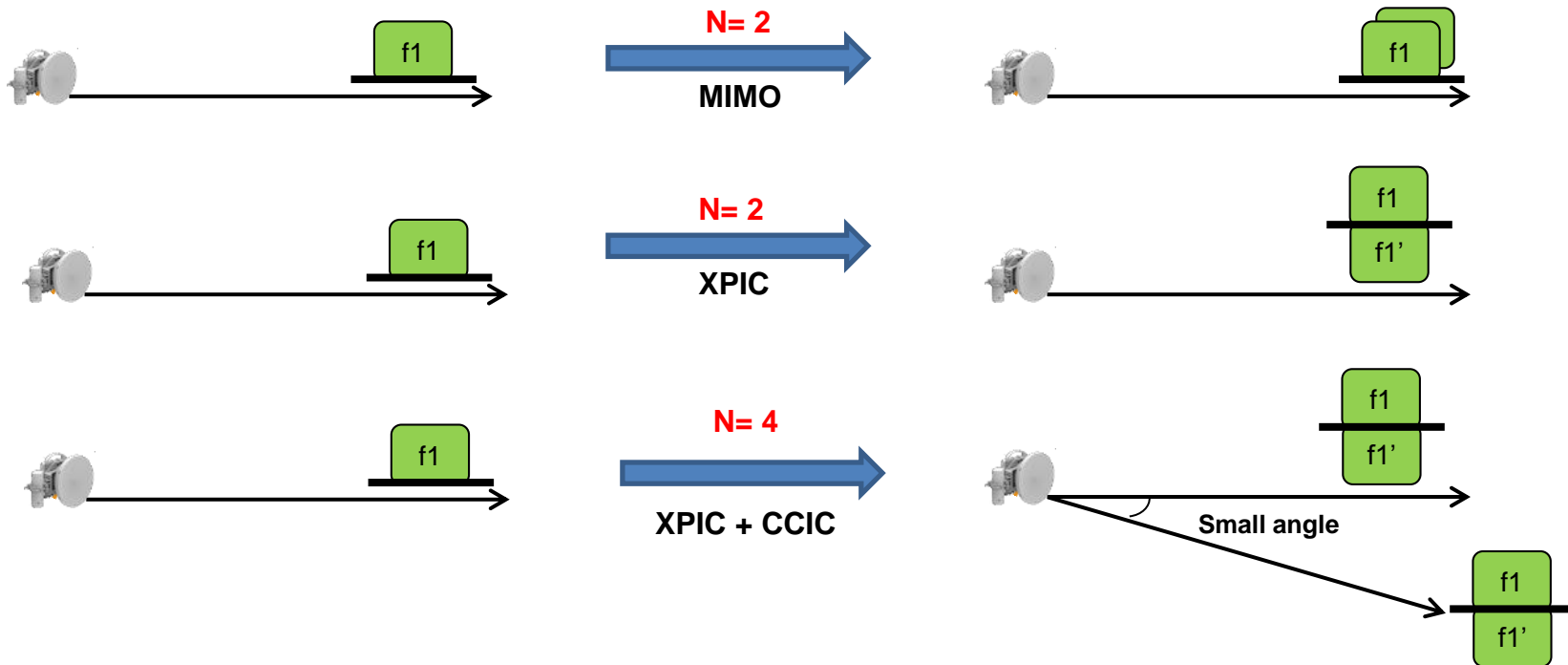
$$\text{License Fees} = k \times BCA \times \left(\frac{1}{fc}\right)^2 \times \frac{BW}{Bsize} \times \left(\frac{1}{N}\right)$$

Including also incentives for geographical spectrum efficiency (MIMO, XPIC, CCIC, etc.)

	Impact	How to consider it for License fee?	Formula factor
1. Larger spectrum availability	Cost per MHz in the shall be smaller when increasing the frequency	License fee proportional to the ratio between Channel bandwidth (BW) and overall Band size (Bsize)	$\frac{BW}{Bsize}$
2. Higher frequency re-use	More links per square km. The same spectrum can be licensed several times over the same area	Coordination area reduction goes with the square of carrier Frequency (fc). License fee proportional to inverse of coordination area.	$\left(\frac{1}{fc}\right)^2$
3. Lower availability at top capacity (higher frequency)	When E-Band is used on links (Band & Carrier Aggregation, BCA) longer than dmax, license fee incentives should be considered	<ul style="list-style-type: none"> Administration to set dmax for E-Band stand-alone link BCA discount factor in case E-Band link distance (d) exceeding dmax 	$BCA = \frac{dmax}{d}$
4. Channel re-use with smaller angles in nodal configurations	More links density in the same geographical area	Factor inversely proportional to number (N) of links / carriers in the same site / node / area re-using same channel	1/N

Examples on how to incentivize “geographical spectrum efficiency”

- Below approach can be adopted today in any Band with individual licensing



Key Aspects for Identifying the Best Licensing

There is not one single best licensing approach for any Band in any Country

- Build a benchmark of what spectrum usage and costs are for some significant Operators across different Bands
- Assess usage of the Band today
 - Greenfield: new Band (very limited deployments)
 - Brownfield: huge installed basis from several Operators
- Assess total amount of available spectrum compared with:
 - Max channel size (as per spectrum regulations & technology)
 - Number of Operators that might require block allocation

Possible ways forward towards Best Licensing

Option #1

OR

- Band usage: **Brownfield**
- Amount of Spectrum: **Limited**



- Go with **Individual Licensing**
- Improving license fee rules to incentivize “**geographical spectrum efficiency**”
- Eventually moving to Hybrid Scheme in the long term in case of no spectrum limitations

Option #2

AND

- Band usage: **Greenfield**
- Amount of Spectrum: **Large**



- Go with a new **Hybrid Scheme**
 - With a **low upfront fee** for block exclusivity
 - With **additional fee per link** (new formula and geographic spectrum efficiency) to ensure efficient spectrum usage
- More innovative spectrum usage in some selected bands to better match downlink/uplink traffic asymmetry

Option #1 - Recommended Regulations for the E-band

License regime	E-band Coordination			
		Coordinated (by Admin)	Self-coordinated (by Licensee)	Uncoordinated (Nobody)
	Individual licensing	YES		
	Light licensing		YES	
	Block allocation		NO	
	License exempt			NO

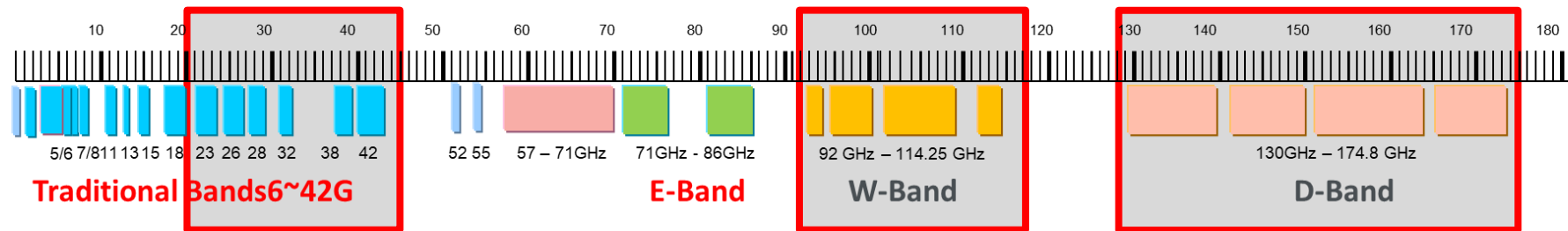
In line with “Coordinated” spectrum approach

- defined by ECC and FCC regulations worldwide
- already implemented by majority of National Regulations

Source “ISG mWT view on V-Band and E-Band Regulations”, mWT-0014v2.0.0, Dec 2017

- Rationale for Individual Licensing is limited spectrum (4.75GHz) vs max channel size (2 GHz)
 - Light Licensing is a good alternative allowing lower spectrum fees & shorter time for spectrum acquisition
- License fees approach to pursuit in the E-Band:
 - Proper base line price according to formula presented before (to achieve a **similar approach across Countries**)
 - Introduction of “**geographical spectrum efficiency**” (coefficient N) for 4G/5G dense urban deployments
 - Introduction of “**Band and Carrier Aggregation**” (BCA factor) to incentivize E-Band in 4G/5G rural deployments

Option #2 - Efficient Use of Spectrum in high MW Bands and mmW



Larger channel size in High MW Bands (23-42 GHz)

- Release **112 and 224 MHz channels**
- Evaluating adoption of **Hybrid Scheme** in greenfield bands such as **32 GHz** (in several Countries) and bands **above 23 GHz** in Far East Countries

Open new mmW bands above 90 GHz

- Large spectrum availability: 15 GHz in **W-Band** and 30GHz in **D-Band**
- Already released to Fixed Service (primary use) – see ECC Rec(18)01 and Rec(18)02
- **Hybrid Scheme** should be first option to evaluate given the fact these bands are greenfield, spectrum availability is huge and spectrum regulations allow for PP/PMP and FDD/TDD usage

Conclusions

- Today backhaul spectrum licensing schemes and fees are not suitable to address 5G X-haul deployments because license fees grow linearly with channel width and time to market is becoming a limiting factor
- Spectrum regulations and licensing need to evolve promoting innovation and making 5G backhaul/X-Haul economically sustainable
- Incentive for “geographical spectrum efficiency” shall be used for Bands with large installed basis or limited spectrum
- New / Greenfield Bands (e.g. 32 GHz, W/D Bands) deserve considering a new approach such as Hybrid Scheme to address 5G economics as well as enabling more innovative X-haul technologies